Oral histology
Periodontal Ligament

The periodontium is a connective tissue organ, covered by epithelium that attaches the teeth to the bones of the jaws and provides a continually adapting apparatus for support of the teeth during function. It comprises of cementum, periodontal ligament, bone lining the tooth socket (alveolar bone) and that part of the gingiva facing the tooth (dentogingival junction). The periodontium is attached to the dentin of the root by cementum and to the bone of the jaws by alveolar bone.

Development of periodontal ligament

The development of the periodontal ligament begins with root formation, prior to tooth eruption. The continuous proliferation of the internal and external enamel epithelium forms the cervical loop of the tooth bud. This sheath of epithelial cells grows apically, in the form of Hertwig’s epithelial root sheath, between the dental papilla and the dental follicle.

At this stage, the sheath forms a circumferential structure encompassing dental papilla separating it externally from dental follicle cells. The dental follicle cells located between the alveolar bone and the epithelial root sheath are composed of two subpopulations, mesenchymal cells of the dental follicle proper and the perifollicular mesenchyme. The mesenchymal cells of the perifollicular mesenchyme bounded by the dental follicle proper and the developing alveolar bone are stellate shaped, small and randomly oriented.

As the root formation continues, cells in the perifollicular area, gain their polarity and the cellular volume and synthetic activity increase. These cells become elongated and contain increased amounts of rough endoplasmic reticulum, mitochondria and occupies the periodontal space, which is located between the cementum and the periodontal surface of the alveolar bone, and extends coronally to the most apical part of the lamina propria of the gingiva. At the apical foramen, it is continuous with the dental pulp. Collagen fibers of the periodontal ligament are embedded in cementum and alveolar bone so that the ligament provides soft-tissue continuity between the mineralized connective tissues of the periodontium.
**Thickness of PDL**

Periodontal ligament ranges in width from 0.15 to 0.38 mm. It is thinnest around the middle third of the root, with an hour glass appearance. It shows a progressive decrease in thickness with age. The periodontal thickness measures about 0.21mm in the young adult, 0.18mm in mature adult, and 0.15mm in older adult.

**Function of PDL**

**Supportive**

When a tooth is moved in its socket as a result of forces acting on it during mastication or through application of an orthodontic force, part of the periodontal space will be narrowed and the periodontal ligament contained in these areas viscoelastic properties. The loaded tooth support system shows elasticity and in the recovery phase to its original position and also phases of movement.

**Sensory**

The periodontal ligament, through its nerve supply, provides a most efficient proprioceptive mechanism, allowing the organism to detect the application of the most delicate forces to the teeth and very slight displacement of the teeth.

**Nutritive**

The ligament contains blood vessels, which provide anabolites and other substances required by the cells of the ligament, by the cementocytes, and presumably by the more superficial osteocytes of the alveolar bone.

**Homeostatic**

It is evident that the cells of the periodontal ligament have the capacity to resorb and synthesize the extracellular substance of the connective tissue of the ligament, alveolar bone, and cementum.

**Eruptive**

The cells, vascular elements and extracellular matrix proteins of the PDL function collectively to teeth of limited eruption to adjust their position while remaining firmly attached to the bone socket.
The PDL provides space and acts as a medium for cellular remodeling and hence continued eruption and approximal shift occurs.

**Physical**

In the periodontal ligament the physical function entails not only protection of vessels and nerves from mechanical forces but also to offer resistance to impact from occlusal forces.

**The Cells of PDL**

The cells of the periodontal ligament may be divided into:

1. Synthetic cells Fibroblasts Osteoblasts
   Cementoblasts
2. Resorptive cells
   Osteoclasts Fibroblasts Cementoclasts
3. Progenitor cells
4. Epithelial rests of Malassez
5. Defense cells
   Mast cells Macrophages Eosinophils

**Synthetic cells**

**Fibroblast**

The *fibroblast* is the predominant cell in the periodontal ligament. These fibroblasts origin in part from the ectomesenchyme of investing layer of dental papilla and from the dental follicle. These cells are different from cells in other connective tissues in a number of respects. For example, the rapid degradation of collagen by fibroblast phagocytosis is the basis for the very fast turnover of collagen in the periodontal ligament.

It is also believed that the periodontal ligament contains a variety of fibroblast cell populations with different functional characteristics. For example, fibroblasts on the bone side of the ligament show abundant alkaline phosphatase activity than those on the tooth side.
Developmental differences may also exist. It has been demonstrated that, the fibroblasts near cementum are derived from ectomesenchymal cells of the investing layer of dental papilla, while fibroblasts near alveolar bone are derived from perivascular mesenchyme.

These fibroblasts are regularly distributed throughout the ligament, and are oriented with their long axis parallel to the direction of collagen fibrils.

The fibroblasts are large cells with extensive cytoplasm and abundant organelles, associated with protein synthesis and secretion. abundant secretory granules containing type I collagen molecules.

**Function**

The role of the fibroblasts is to produce the structural connective tissue proteins, collagen and elastin, as well as proteoglycans, glycoproteins and glycosaminoglycans that comprise the periodontal ligament ground substance.

The fibroblasts of periodontal ligament are characterized by rapid turnover of extracellular matrix in particular collagen. The fibroblasts are responsible for the formation and remodeling of the periodontal ligament fibers, and a signaling system to maintain the width of the periodontal ligament and thickness across the soft tissue boundary defined by this ligament.

**Osteoblasts**

The osteoblasts covering the periodontal surface of the alveolar bone constitute a modified endosteum and not a periosteum.

**Cementoblasts**

These cells line the surface of cementum, but are not regularly arranged as osteoblasts. These cells are often indistinguishable from periodontal fibroblasts apart from their location adjacent to cementum surface.

**Resorptive cells**

**Osteoclasts**

Osteoclasts are cells that resorb bone and tend to be large and multinucleated or small and mononucleated cells.
Fibroblasts

These cells show rapid degeneration of collagen by fibroblast phagocytosis and that is the basis for fast turnover of collagen in periodontal ligament.

Cementoclasts

Cementoclasts resemble osteoclasts and are occasionally found in normal functioning periodontal ligament. In these instances mononuclear cementoclasts or multinucleated giant cells, often located in Howship’s lacunae, are found on the surface of the cementum. Important in resorption of cementum.

Progenitor cells

All connective tissues, including periodontal ligament, contain progenitors for synthetic cells that have the capacity to undergo mitotic division. If they were not present, there would be no cells available to replace differentiated cells dying at the end of their life span or as a result of trauma.

Epithelial rests of Malassez

The periodontal ligament contains epithelial cells that are found close to the cementum. These cells are the remnants of the epithelium of Hertwig’s epithelial root sheath. At the time of cementum formation, the continuous layer of epithelium that covers the surface of the newly formed dentin breaks into lacelike strands. The epithelial rests persist as a network, strands, islands, or tubule-like structures near and parallel to the surface of the root.

Fibers

The connective tissue fibers are mainly collagenous, but there may be small amounts of oxytalan and reticulin fibers, and in some species, elastin fibers.

Collagen

The collagen is gathered to form bundles approximately 5 μm in diameter. These bundles are termed principal fibers. Within each collagen bundle, subunits are present called collagen fibrils.

The main types of collagen in the periodontal ligament are type I and type III. More than 70% of periodontal ligament collagen is type I.
**principal fiber**

Run between cementum and bone and is the *alveolodental ligament*, which consists of five fiber groups: alveolar crest, horizontal, oblique, apical and interradicular group in multirooted teeth.

1. **Alveolar crest group** Alveolar crest fibers extend obliquely from the cementum just beneath the junctional epithelium to the alveolar crest.

2. **Horizontal group** These fibers run at right angles to the long axis of the tooth from cementum to alveolar bone, and are roughly parallel to the occlusal plane of the arch.

3. **Oblique group** Oblique fibers are the most numerous and occupy nearly 2/3rd of the ligament. These fibers are inserted into the alveolar bone at a position coronal to their attachment to cementum.

4. **Apical group** From the cementum at the root tip, fibers of the apical bundles radiate through the periodontal space to become anchored into the fundus of the bony socket.

5. **Interradicular group** The principal fibers of this group are inserted into the cementum from the crest of interradicular septum in multirooted teeth.

**Sharpey’s fibers**

Collagen fibers are embedded into cementum on one side of the periodontal space and into alveolar bone on the other.

**Gingival ligament fibers**

The principle fibers in the gingival area are referred to as gingival fiber. Which are:

- **dentogingival group** - there are three types of fibers within this group:
  - fibers that extend towards the crest of the gingiva
  - fibers that extend laterally to the outer surface of the gingiva
  - fibers that extend outward, past the height of the alveolar crest, and then downward along the cortex of the alveolar bone.
- **circular group** - these fibers are unique in that they exist entirely within the gingiva and do not contact the tooth.
- **transseptal group** - these fibers have traditionally been described as spanning the interproximal tissue between adjacent teeth, into which they
are embedded. However, two other types of fibers have been described in this group:

- **semicircular fibers** - fibers that run through the facial and lingual gingiva around each tooth, attaching to the interproximal surfaces of the same tooth.
- **transgingival fibers** - fibers that run between two non-adjacent teeth and are embedded in the cementum of their proximal surfaces, passing around the tooth in the middle of the two teeth attached with these fibers.

**Oxytalan Fibers**
Elastic like fibers that run parallel to the tooth surface and bend to attach to cementum. Fibrillin builds the oxytalan fibers, which causes the elastic behavior. In the cellular anatomy of teeth, oxytalan fibres are a component of the extracellular matrix.

**Function:** Regulate vascular flow in relation to tooth function.

**Ground substance**
Within the periodontal ligament are, blood vessels, lymph vessels, nerves and connective tissue cells interspersed in an extracellular matrix containing collagens and the ground substance. Ground substance has been estimated to contain 70% water and is thought to have a significant effect on the tooth’s ability to withstand stress loads.

The ground substance is a gellike matrix. The functions of ground substance are ion and water binding and exchange, control of collagen fibrillogenesis and fiber orientation and binding of growth factors. The ground substance consists mainly of glycosaminoglycans, proteoglycans and glycoproteins. All components of the ground substance are presumed to be secreted by fibroblast.

**Blood vessels**
The periodontal ligament is a high fiber density tissue with abundant vascular supply.

**Arterial supply.** The blood supply is derived from the inferior and the superior alveolar arteries to the mandible and maxilla respectively and reach the PDL from three sources:

1. Branches in the periodontal ligament from apical vessels that supply the dental pulp.
2. Branches from intraalveolar vessels. These branches run horizontally, penetrating the alveolar bone to enter the periodontal ligament.
3. Branches from gingival vessels. These enter the periodontal ligament from the coronal direction.
Venous drainage.

These are channels receive blood from the capillary network and also specialized shunts called glomera in the PDL.

Nerves

The PDL has functionally two types of nerve fibers: sensory and autonomic. The sensory fibers are associated with nociception and mechanoception, with touch, pressure, pain and proprioceptive sensations. The autonomic fibers are associated with PDL vessels. All PDL innervations are mediated by the dental branches of alveolar nerves which enter through apical perforation of the tooth socket and perforating branches of interalveolar nerves traversing the bone. The nerve fibers are either of large diameter and myelinated or of small diameter, in which case they may or may not be myelinated.

Cementicles

Calcified bodies called cementicles are sometimes found in the periodontal ligament. These bodies are seen in older individuals, and they may remain free in the connective tissue, they may fuse into large calcified masses, or they may be joined with the cementum. As the cementum thickens with advancing age, it may envelop these bodies. When they are adherent to the cementum, they form excementoses. The origin of these calcified bodies is not established. It is possible that degenerated epithelial cells form the nidus for their calcification.

Interstitial tissue

Interstitial connective tissue is a loose connective tissue that contains blood vessels, lymphatics, nerves and less regularly arranged collagen fibers.

AGE CHANGES IN PERIODONTAL LIGAMENT

The PDL ages as in all other tissues of the body. The cell number and the cell activity decreases with aging. One of the prominent age changes is seen in the calcified tissues of the periodontium, the bone (alveolar) and the cementum, is scalloping and the PDL fibers are attached to the peaks of these scallops than over the entire surface as seen in a younger periodontium. This remarkable change affects the supporting structures of the teeth. With aging the activity of the PDL tissue decreases because restricted diets and therefore normal functional stimulation of the tissue is diminished. Any loss of gingival height related to gingival and periodontal disease promotes destructive changes in the PDL. Some the teeth becomes nonfunctional and the PDL width also starts to diminished.